

Mr. WRIGHT said, the mode of descent into metallic mines, by means of ladders of various lengths placed in different positions, rendered necessary by the diversified form of the shaft, owing to frequent breaks in the metallic lodes, and the eccentric courses in which the lodes ran, differed from that into a coal-mine, the shaft of which could, in most cases, be continued in a circular form, in a perpendicular course, to the depth required. On account of the hardness of the material, the shaft of a metallic mine in Cornwall was generally made as small as possible, and in some parts was only sufficient to admit of the passage of the body through the hole. The effect of upwards of one hundred men passing down the ladders, one after the other, each with a lighted candle in front of his hat, to the depth of 700 feet, was peculiar. The vapour thus inhaled by the men from those preceding them was described as being of a most sickening character, and he would prefer descending double the distance where the shaft was lighted with gas. The difficulty which had hitherto prevented the lighting of mines with gas appeared to arise from the want of pressure in the gas. In the lighting of towns, the pressure employed seldom exceeded a column of water 3 inches in height, and in many cases it was less than that. This pressure was, of course, quite insufficient for the purpose. Again, gas manufacturers had a dread of leakage, and arguing from the experience of the streets of the metropolis, the opinion was entertained, that with a pressure of 18 inches, half the gas would be lost by leakage in the mains. In adopting high-pressure gas for mines, he however took the precaution to use wrought-iron pipes and tubes, well prepared, through the pores of which he believed gas could not exude. He also employed pipes of small diameter, as with high-pressure gas it was not necessary to be so conservative of what was called pressure, and he had allowed 4 inches of pressure for the friction along the pipes. It was, therefore, a question of small pipes, to do a large amount of work, under a high pressure; and in this respect a saving was effected in the fitting of a mine with gas. In the first instance, some difficulty was experienced by the workmen in fitting the pipes through the narrow, irregular passages of the shaft; but the men soon got accustomed to the work, and now, notwithstanding that the rock had in some cases to be blasted, an operation which the fitters learnt to perform with as much facility as the miners, the work was rapidly and easily effected. In the introduction of this plan, as might be expected, there were many prejudices to be overcome. The objection taken in the first instance was, that gas could not be sent down to a greater depth than 60 fathoms. After it had been proved, that the gas could be transmitted to any required depth, it was conceded that the plan would answer for lighting the men up and down the shaft, but that when carried to

the working-chambers, the concussion from the gunpowder used in blasting would extinguish the gas, and that the heat generated would be much greater than was the case with candles. With reference to the first objection, it had been ascertained, by experiment, that not a single gas-light was extinguished by the explosions, whereas at the same distance the miners' candles were invariably put out. The plan had been so far carried out, that at the present time, there were two hundred and fifty men working in a mine by gas-light. He had recently received a letter from Mr. Richard Davy, nephew of the great Sir Humphry Davy, and purser of the mine, speaking in the highest terms of the utility and benefits to be derived from this new application of gas.

There was a wide distinction to be drawn between coal and Cornish mines. In the latter, from the works not proceeding so rapidly, less alteration and extension of the gas-fittings was required, and they were free from explosive gases. On the other hand, with the perpendicular and uninterrupted shaft of a coal-mine, the expense of fitting the gas would not be more than one-half, or perhaps one-fourth, that of fitting the shaft of a metallic mine, owing to the intricacies of the shaft. He thought the lighting of the tramways of mines with gas would be attended with great advantage. In Cornwall, it had been found that it enabled the ore to be transmitted with greater speed and certainty. In the case of coal-mines, owing to the work advancing so much more rapidly, it might be necessary to have an attendant gas-fitter to a certain number of miners, in order to extend the fittings as required. He believed, if the system was introduced into the shafts and tramways of coal-mines, it would speedily find its way into the chambers, and that there would be no greater liability of explosions from gas than from candles. A miner working with a Davy lamp had two-thirds of the light obscured by the wire-gauze, leaving only one-third of the light to work by. Being anxious to increase his earnings, he was induced at times to open the lamp, and thus to hazard his life, rather than to work with an obscure light. If, therefore, the miner had a light equal to ten candles, which, with the protection of the Davy lamp, would be equal to three-and-a-half candles, the inducement to neglect the precautions for the prevention of explosions would be lessened. He had a strong conviction that, under proper regulations, the system would be as successful in coal-mines as it had been proved to be in metallic mines.

Mr. G. R. BURNELL called attention to a note by M. Gonot upon the introduction of the system of lighting mines by means of coal gas.¹ The experiment referred to by M. Gonot was tried in

¹ Vide "Annales des Travaux Publics de la Belgique." Tom. v. (1857), p. 341.

the Pit No. 2 of the mines known by the name of the "Vingt quatre actions, du Rieu du Cœur," in the commune of Quaregnon, about five miles west of Mons. It was authorised by a Royal Decree, dated 28th August, 1844, after a careful investigation by the Government Engineers.

The gas apparatus was established at 876 feet, nearly, from the surface, to the south of the descending shaft. It consisted of two furnaces, (each of which contained two retorts,) a hydraulic main, a washer which also served as a condenser, a purifier, and a gas-holder. The whole apparatus occupied a space of about 33,000 cubic feet, which was entirely excavated in the solid rock. The products of combustion under the retorts were carried directly to the ascending shaft. The retorts were semi-cylindrical, about 2 feet in diameter, and 7 feet 6 inches long. The tank for the holder was 13 feet 9 inches diameter, and 13 feet 2 inches deep, nearly filled with water; and it received a wrought-iron gas-holder, 13 feet 2 inches diameter by 12 feet 9 inches deep. The ordinary pressure on the outlet was $1\frac{1}{2}$ inch. The coal distilled in the retorts was the kind known by the name of the Flenu. The charges varied in amount from 132 lbs. to 176 lbs., and in time from four hours to six hours, yielding, on an average, about 9,000 cubic feet of gas per ton. A foreman, stoker, and an assistant by day, and a third workman by night, kept up the supply of gas, and maintained the various parts of the machinery in working order. The descending shaft was lighted by sixteen gas-burners, supplied from a lead pipe of about 1·8 inches internal, and 2·7 inches external diameter. The gas was made to descend about 36 feet to the roadways, and was then carried through the various galleries to the face of the work, situated at a distance of about 1,710 feet from the up-cast shaft. The Government Engineers, it might be added, stipulated in the Royal Decree authorising this work, for a number of insignificant and vexatious precautions, in the manufacture and application of the gas, which were quite useless, and which appeared to have been practically disregarded.

M. Gonot found that the expense of lighting the mine in this manner was far greater than that of lighting the working parts by means of moveable lights. He attributed this result to, 1°, the cost of preparing the position destined to receive the factory; 2°, the extra cost of the factory itself, erected in such a position; and, 3°, the cost of manufacture. The latter was indeed exorbitant, for three workmen ought to suffice for five times the number of retorts usually worked in this mine. M. Gonot was evidently disposed to believe, that it would be preferable to manufacture the gas on the surface, and to force it down to the bottom of the mine. In order to obviate the injurious action which might

take place on the retorts, by the high pressure required under that condition upon the outlet, he suggested the use of an intermediate holder. He, however, decidedly expressed his opinion, that the success of the system of lighting coal-mines with gas had been established in principle, although there were many practical difficulties still to be overcome, before it could be generally applied. The interference of the gas apparatus with the ventilation of the mine, seemed to have been one of the most serious objections to this particular experiment.

Mr. Burnell had subsequently ascertained, that this system of lighting had been abandoned, but for what precise reasons he had been unable to learn.

Mr. HARTNUM remarked, with reference to the discontinuance of gas-lighting in the Belgian mines, that the coal of Mons was not so well suited for the purposes of gas-making as that obtained in England. Hence the use of that coal for such purposes had been discontinued throughout the south of France, in many parts of the north of France, and in Paris to a great extent.

Mr. LONGRIDGE stated, that a discussion on this subject, though not in a formal shape, had taken place at the North of England Institute of Mining Engineers, in Newcastle. There were at present two mines in the north of England partially lighted with gas, the Seaton Delaval and the Townley Mine. In the first case, the gas was made underground, and lighted the shaft and part of the main ways, but was not employed in the workings. He thought there would be difficulties in bringing it into the workings, as the 'creep,' or heaving of the floor, would render the gas-pipes liable to be fractured, and, if successful in this point, that the lights could not be so readily applied as in a Cornish mine. In coal-mines each man worked in his own 'board,' and each must have his own light; but by a proper arrangement of flexible tubes, that difficulty might perhaps be overcome. He explained that there were two operations in the working of a coal-mine, as generally practised in the North of England. First, galleries, or 'boards,' were driven throughout a district of a certain extent, large pillars of coal being left to support the roof. This was called 'working the whole coal.' At a subsequent period, these pillars were removed, which was called 'working the broken.' When the pillars were removed throughout one of these districts, or 'panels of boards,' as they were called, the roof fell, and the district then became what was technically called a 'goaf.' In the Townley Mine the natural gas from a large blower was collected, and after being passed through water, was employed for lighting. The gas was carried into the shaft, and into some of the main ways at the bottom of the shaft, and he believed, also, to the surface, for lighting the engine-house.

As far as his own opinion at present went, the only safe method of working coal-mines was with the safety-lamp. With respect to the condition of the explosive gases in coal-seams, present information seemed to show, that it was extremely uncertain at what place the gas would make its appearance. Upon a review of the principal accidents that had occurred in the mines in the North of England, it would be found, that the injury had not occurred in the broken portions, but in the whole portions of the coal. A Paper on this subject by Mr. Taylor was recorded in the first volume of the "Transactions of the North of England Institute of Mining Engineers," in which a case was mentioned of a mine at one moment being perfectly free from gases, then a large discharge of gas took place, and half an-hour afterwards the mine was again free from gas. That gas, if not in a liquid state, existed in a state of very high tension; and when the pillars were worked, the gas gradually drained off. But the chief danger was not when they worked the pillars off, but in working the whole coal, for then they came suddenly upon gas *in situ*, in a high state of tension, and then it was that accidents occurred from working with unprotected candles.

Mr. F. A. WINSOR remarked, that the only question which arose in his mind was as to the pressure. It was quite true that Gas Companies, in general, were not disposed to work at a high pressure, because it resulted in a considerable loss of gas from leakage in the mains. Taking gas from an elevated situation, and securing a uniform light at a low level, was a matter of some difficulty, more especially where the fittings were of a small diameter. Throughout London generally, the gas was worked at a pressure of about $2\frac{1}{2}$ inches only. The Brick-lane station of the Chartered Gas Company had supplied gas to the district of Clerkenwell, descending from the station to that point, and rising again at Oxford-street. The loss of pressure was very considerable by the time the gas got to Clerkenwell, but by its levity and elasticity, the pressure was gained when it reached Oxford-street. Instances had occurred when there was scarcely any light at Clerkenwell, and yet at Oxford-street, from the same main, a flame of 6 inches could be obtained. He mentioned this, as an example of the difficulty of lighting a low situation.

Mr. PERKINS remarked, that gas had been introduced into the Sherburn Colliery, the property of the Earl of Durham, for lighting the banks, the top and bottom of the shafts, the stables, and the immediate vicinity; and with such success, that it was in contemplation to adopt the same system in four more of his Lordship's collieries. At Bedlington Colliery, in Northumberland, the 'bank establishment,' as it was called, was lighted by gas, but the gas was not taken into the pit. He was not aware of any

instance in which the gas was introduced into the actual 'workings' of the colliery. He believed that great timidity prevailed amongst miners upon this point, on account of the extent of the fittings required, and the damage it was apprehended the pipes would sustain, from accidents in the mine.

Mr. THOMAS HAWKSLEY said, as far back as eight, or ten years ago, he was consulted with reference to the introduction of gas into coal-mines; in one case in a mine in Northumberland, and in another instance in a mine—or rather a cluster of mines—in Nottinghamshire. With regard to the source from which the gas should be supplied, he came to the conclusion, that it was not desirable for any establishment, formed for the supply of gas to a town, to complicate itself with the supply of gas to mines—the circumstances being so widely different; but that mines ought to be supplied with gas from establishments to be erected for the express purpose. With reference to coal-mines, as a general rule they were worked, more or less, by day and by night, and therefore, as regarded the surface works and shafts, it was very desirable that gas should be introduced. Its introduction into the underground workings must depend upon the particular nature of the mine, whether it was a fiery mine, or not—whether it was well, or ill ventilated—and upon the particular manner in which the mine was worked. In one case the roof was liable to come down, and in another the roof would stand. In one case the whole of the minerals would be brought out, and in another only a portion. Reference must also be had to the manner in which the workings were conducted; because it was quite manifest, that it would be impossible to be continually altering the lines of pipes in a mine, so as to afford the necessary facilities of light to the workmen. If pipes were laid to a great extent, and some mines extended for miles, it would be impossible to be continually removing the pipes from one situation to another. Then again there was danger of leakage, for although the pipes might be perfectly sound when fitted, yet in coal-mines they were liable to accident from the falling of the roof, from 'creeps,' from rapid decay, and from other causes. Besides which he did not think it feasible, as a general rule, to introduce gas into coal-mines, without the protection of the safety-lamp, which it would be difficult to apply to it. There was no doubt, that gas could be readily taken down mines of great depth, because the levity of gas compared with atmospheric air, could be overcome by a corresponding pressure from above; and therefore gas could be as easily used in a deep mine as on the surface. Every 10 feet of depth required $\frac{1}{10}$ th of an inch of water-pressure, to drive Newcastle coal-gas of ordinary density down the pit. A mine 2,000 feet deep would take 20 inches of water-pressure, to drive the gas to the bottom, to which must be added the

resistance from friction, which was to be calculated according to the circumstances of each case. With the facts all given, it was easy to determine the dimensions of the distillatory, storage, and distributory works necessary for lighting a mine, and their cost. But there were so many circumstances under which explosions took place in fiery mines, that his experience led him to think, that under the existing methods of working, gas could not be safely carried to the face of the coal, in mines where any risk of explosion existed. As to many other mines, he did not think there was any physical difficulty whatever.

Mr. WRIGHT said, in reply to questions from different members, that all the lights in the shaft, and along the passages leading to the workings, were lighted when the first gang of men went to work; when the second gang returned, after the day's work was finished, a boy followed and extinguished the lights, until they were again required. He had not at present decided upon the exact mode he should recommend, for lighting safety gas-lamps, but it might be done in various ways; possibly a plan something like Mr. Gurney's might be adopted. If there was a number of lights burning, there would only be a series of small explosions, and a large one could hardly occur. It was not necessary, nor customary he believed, to employ mechanical means to send the gas into the Thames Tunnel, as had been hinted at. In the Western Gas Company's works, at Kensal Green, a pressure of $4\frac{1}{2}$ inches was employed. The mains ran on a descent to Buckingham Palace, and the works themselves were about 80 feet above the level of the district they lighted, which was relatively lower than the Thames Tunnel. The pipes were made large in a town to save friction. His present purpose, however, was to show the perfect feasibility of lighting metallic mines with gas, to be sent down by mechanical force. The specific part of his system was to make the gas at the top of the mine, and use high-pressure gas. The leakage in the street mains, which had been referred to, arose from the employment of cast-iron pipes of rough make, with caulked lead joints, and subject to a variety of disturbing causes from heavy traffic, &c. The system he started upon was, if pipes were made of wrought-iron of small diameter, and perfectly sound, there would be no leakage at all. The last time he was down the Balleswidden mine, he had examined the fittings joint by joint, and did not discover the least leakage. He further explained that, at the junction with the flexible tube, it became low-pressure gas, from the cock being turned off at that particular point. With reference to the manufacture of gas at the bottom of the mine, it was not only a dangerous process, but the works occupied a great deal of space, and upon the whole the manufacture under such circumstances was twice, or three times dearer,

than under the ordinary plan of works above ground. Another plan was to put the gas-holder at the bottom of the mine, the gas being drawn down by a fan, and put into the gas-holder, for the purpose of keeping about $\frac{1}{2}$ inch of pressure. Altogether, he had the most sanguine expectations, that the plan of lighting mines with gas, which he had introduced, would, in time, entirely succeed.

Mr. R. STEPHENSON, M.P., President, congratulated the Institution on having a Paper, the first of the Session, which promised to lead to very important results to the mining community, one of the most extensive interests in this country. The statements brought forward were entirely of an experimental character, and were not based upon theories. The cost, and also the methods, by which a Cornish mine had been successfully lighted, were given. The facts were clearly and simply stated, and he had no doubt, but that the system might be extended to all metallic mines, where there were no explosive gases, and where the progress of the working was so slow and gradual, that the pipes would not require much alteration from week to week, or from month to month. Under these circumstances, he believed it might be adopted with great advantage. But, turning his attention now to those mines with which he was more familiar, he thought that its application to coal-mines must be extremely limited. In the first place, it must be limited to those mines where carburetted hydrogen gas was not found, except in small quantities, and where ventilation was carried out to an enormous extent. It had been stated, that gas might be applied in coal-mines to all the lights about the pit, to the shaft, to the stables, and to the fresh-air courses near the shaft. But any one who had been in the habit of trusting his life in a dangerous coal-mine every morning, as miners had to do, would, he thought, find great difficulty in introducing any system of pipes, excepting in the main thoroughfares. Again, the work proceeded so rapidly, that the expense of keeping the gas up to the working faces would be so great as, in his opinion, to neutralise the advantage of that system of lighting, supposing no carburetted hydrogen gas to exist in the mine. The system of pipes would have to be altered at least every two, or three months, for the thoroughfare which was opened one day had frequently to be abandoned two months afterwards. Therefore, he did not think it possible to apply gas to coal-mines in detail. Another point was, that lights were not required for reaching the distant parts of a mine, when the workings, as sometimes happened, were a mile away from the shaft. In the mine in which he was brought up, it was indifferent to him whether he had a light, or not, in traversing the main thoroughfare; he pursued his way in the dark without apprehension. It was very different in

Cornwall, where the shaft was not so distant. Though 'creeps' had been mentioned as an objection, he thought that such were exceptional cases, except in old mines. Coal-mines, generally speaking, were now worked at such a depth, and were for the most part so productive of carburetted hydrogen, either in a gaseous or in a liquified state, that, as had been already stated, a mine might be filled with the gas at one hour, and the next half hour be entirely free from it; and extensive accidents occurred, from the peculiar position in which gas existed in the coal. The application of this system to coal-mines would consequently be beset with danger, from the presence of carburetted hydrogen gas, and in the great majority of mines of any depth, he felt convinced that it would not be prudent to interfere, in such cases, with the use of the safety-lamp; indeed the conviction was gaining ground, that nothing but safety-lamps should be used, except in the immediate vicinity of the shaft. He did not think, that the application of the principle of the safety-lamp to gas-lighting was so simple as, at first sight, it might appear to be, but that it was a problem difficult of solution, and which had not at all been answered in the course of the discussion.

APPARATUS FOR ASCENDING INCLINED PLANES OF RAILWAYS.

After the meeting Signor de Cristoforis exhibited and explained an apparatus proposed for aiding in the ascent of steep inclines. The system consisted in attaching to the periphery of the driving-wheels of the engine a number of small wheels, which, abutting against a series of cogs connected with the rails, it was assumed would constantly support the train in its ascent.
